



**UNIVERSITI PUTRA MALAYSIA**

**EFFECT OF RADIATION ON DOSIMETRIC AND OPTICAL  
PROPERTIES OF DYED PVA/CH AND DYED PVB/CH BLENDS**

**AZLINA BINTI BAHA.**

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**By**

**AZLINA BINTI BAH**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in  
Fulfillment of the Requirements for the Degree of Master of Science**

**July 2005**



## *DEDICATIONS*

*To my lovely husband, Abd. Aziz Sadri,  
my father, Baha Yeop and my mother, Sitah Alang Aziz, and family  
for their love, support and concern....*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirements for the degree of Master of Science

**EFFECTS OF RADIATION ON DOSIMETRIC AND OPTICAL PROPERTIES  
OF DYED PVA/CH AND DYED PVB/CH BLENDS**

**By**

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**July 2005**

**Chairman : Ascc. Prof. Dr. Zainal Abidin Talib**

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Crystal violet doped polyvinyl alcohol blended with chloral hydrate (CV doped PVA/CH) and methyl green doped polyvinyl butyral blended with chloral hydrate (MeG doped PVB/CH) films were prepared by solvent casting method. The blends were irradiated with  $\gamma$  radiation at doses of up to 110 kGy. The dosimetric and optical characteristics of the irradiated and unirradiated polymer blends were studied using UV-Vis-NIR and Raman Spectrometer.

The CV doped PVA/CH blends change colour from violet to blue at high dose (40 to 60 kGy) before bleaching at higher doses due to the formation of acid by radiation induced dechlorination of CH. The absorption spectra was measured and analysis spectrometrically. The absorbance at the absorption band at 590 nm, the characteristic of

violet colour, decreases with increasing dose. The dose sensitivity  $D_0$  increases where the values were 54.6, 81.9, 84.0 and 117.6 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively. On the other hand, the absorbance at the absorption band at 620 nm, the characteristic of blue colour, also decreases with increasing dose. The dose sensitivity  $D_0$  increases where the values were 81.9, 94.3, 100.0 and 109.1 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively. The consumption of CH has been studied using Raman spectroscopy by observing the reduction of C-Cl bond peak intensity at  $780\text{ cm}^{-1}$ . The Raman intensity decreases with increasing absorbed dose, which produces the dose sensitivity  $D_0$  where the values were 35.3, 52.6, 98.0 and 114.9 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively.

The influence of  $\gamma$  rays on CV doped PVA/CH and MeG doped PVB/CH blend films leads to bond scission and structural order/disorder changes, which reflected in the electronic transitions in the film and can be described by the empirical Urbach rule. The absorption edge,  $E_{\text{opt}}$  for CV doped PVA/CH decreases strongly with the increase of absorbed dose. However, it decreases slightly with the increase of CH concentration. The overall values decrease from 3.74 eV to 3.22 eV for doses up to 110 kGy and CH concentration from 2 g to 5 g. The optical activation energy,  $\Delta E$  increases from 0.282 to 0.524 eV with the increase of CH concentration from 2 g to 5 g CH respectively at zero dose. The value does not change significantly with the change of dose from 20 kGy to 80 kGy and CH concentration from 2 g to 5 g CH. The values obtained are from 0.62 to 0.71 eV. At dose 100 kGy,  $\Delta E$  is higher from 0.834 eV to 0.908 eV for CH concentration at 2 g to 5 g CH, except at 3 g the value was found to be 1.025 eV. The

optical energy band gap,  $E_g$  value for CV doped PVA/CH blend films decreases with increasing dose and CH concentration for direct and indirect allowed transitions. The values of the direct optical energy band gap,  $E_g$  are from 3.64 eV to 4.00 eV, while for indirect optical band gap are from 2.84 eV to 3.60 eV.

The MeG doped PVB/CH blends show no colour change but starts to bleach at lower  $\gamma$ -ray doses of 25 kGy. The absorbance at the absorption band at 425 nm, the characteristic of yellow colour, decreases with increasing dose. The dose sensitivity  $D_0$  increases where the values were 13.5, 16.7, 18.7 and 23.0 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively. On the other hand, the absorbance at the absorption band at 650 nm, the characteristic of green colour, also decreases with increasing dose. The dose sensitivity  $D_0$  increases where the values were 14.5, 16.4, 19.5 and 20.9 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively. Analysis from Raman spectra show that the intensity of C-Cl bond at  $780\text{ cm}^{-1}$  decreases with increasing absorbed dose. The dose sensitivity  $D_0$  increases where the values were 8.2, 9.5, 15.5 and 20.5 kGy for CH concentration at 2.0, 3.0, 4.0 and 5.0 g CH respectively.

The absorption edge,  $E_{\text{opt}}$  for MeG doped PVB/CH decreases strongly with the increase of absorbed dose. Nevertheless, it decreases slightly with the increase of CH concentration. The overall values decrease from 3.68 eV to 3.25 eV for doses up to 25 kGy and CH concentration from 2 g to 5 g CH. The optical activation energy,  $\Delta E$  increases with increasing of doses and CH concentration. The value does not change significantly at zero dose where the value obtained from 0.1010 to 0.1404 eV for 2 g to 5

g CH respectively. The overall values increase from 0.1010 eV to 0.7355 eV for doses up to 25 kGy and CH concentration from 2 g to 5 g CH. The optical energy band gap,  $E_g$  value for MeG doped PVB/CH blend films decreases with increasing dose and CH concentration for direct and indirect allowed transitions. The values of the direct optical energy band gap,  $E_g$  are from 3.79 eV to 3.57 eV, while for indirect optical band gap are from 3.62 eV to 2.90 eV.

In conclusion, was shown radiation effects by  $\gamma$ -rays on CV doped PVA/CH and MeG doped PVB/CH blend films, which affected the dosimetric and optical properties, could be evaluated with suitable reproducibility by measuring the optically stimulated.



Abstrak tesis yang dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan Ijazah Master Sains

**KESAN RADIASI TERHADAP CIRI-CIRI PENGUKUR DOS DAN OPTIK  
BAGI FILEM CAMPURAN PVA/CH DAN PVB/CH YANG BERWARNA**

**Oleh**

**AZLINA BINTI BAH**

**July 2005**

**Pengerusi : Prof. Madya Dr. Zainal Abidin Talib**

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Cristal ungu yang didopkan bersama campuran polivinil alcohol dengan kloral hidrat (CV dop PVA/CH) dan metil hijau yang didopkan bersama campuran polivinil butiral dengan kloral hidrat (MeG dop PVB/CH) disediakan dengan menggunakan teknik acuan. Filem tersebut diradiasikan dengan sinar  $\gamma$  sehingga 110 kGy. Ciri-ciri pengukur dos dan optik bagi campuran CV dop PVA/CH and MeG dop PVB/CH dianalisis menggunakan alat UV-Vis-NIR dan Raman Spektrometer.

Campuran CV dop PVA/CH bertukar warna dari warna ungu ke warna biru pada purata dose dari 40 hingga 60 kGy sebelum meluntur warna pada dos yang lebih tinggi hasil dari pembentukan asid kesan dari radiasi yang menyebabkan pengklorinasi CH. Spektrum serapan telah diukur dan dianalisis. Penyerapan pada puncak 590 nm,



mencirikan warna ungu menurun dengan peningkatan dos. Sensitiviti dos,  $D_0$  meningkat di mana nilainya adalah 54.6, 81.9, 84.0 and 117.6 kGy bagi kandungan CH 2.0, 3.0, 4.0 dan 5.0 g masing-masing. Selain itu, penyerapan pada puncak 620 nm yang mencirikan warna biru juga menurun dengan peningkatan dos. Sensitivity dos,  $D_0$  menurun di mana nilainya adalah 81.9, 94.3, 100.0 and 109.1 kGy bagi kandungan CH pada 2.0, 3.0, 4.0 dan 5.0 g masing-masing. Kepenggunaan CH telah dikaji menggunakan Raman spectrometer dengan memerhati penurunan keamatan ikatan C-Cl pada  $780\text{ cm}^{-1}$ . Keamatan ikatan C-Cl menurun dengan peningkatan dos, di mana sensitiviti dos,  $D_0$  adalah 35.3, 52.6, 98.0 and 114.9 kGy bagi kandungan CH masing-masing pada 2.0, 3.0, 4.0 dan 5.0 g.

Kesan sinar  $\gamma$  terhadap campuran CV dop PVA/CH dan MeG dop PVB/CH memutuskan ikatan dan berlaku perubahan struktur bahan, yang mana memberi kesan terhadap peralihan elektronik di dalam sampel seperti yang dinyatakan oleh hukum Urbach. Nilai  $E_{\text{opt}}$  bagi CV dop PVA/CH didapati jelas berkurang dengan peningkatan dos tetapi tidak jelas dipengaruhi oleh kandungan CH. Keseluruhan nilainya adalah dari 3.74 eV hingga 3.22 eV pada kandungan CH masing-masing dari 2.0 hingga 5.0 g setelah diradiasikan sehingga 100 kGy.  $\Delta E$  meningkat dari 0.282 hingga 0.524 eV bagi kandungan CH dari 2.0 hingga 5.0 g pada 0 kGy. Nilai  $\Delta E$  tidak jelas berubah dari dos 20 kGy hingga 80 kGy masing-masing pada 2.0 dan 5.0 g CH. Nilai yang diperolehi adalah dari 0.62 to 0.71 eV. Pada dos 100 kGy,  $\Delta E$  lebih jelas meningkat dari 0.834 eV to 0.908 eV masing-masing pada kandungan 2.0 dan 5.0 g CH, kecuali pada 3.0 g CH di mana nilainya adalah 1.025 eV. Nilai  $E_g$  oleh campuran CV dop PVA/CH menurun dengan

peningkatan dos dan kandungan CH bagi  $m=1/2$  dan  $m=2$ . Nilai  $E_g$  bagi  $m=1/2$  adalah dari 3.64 eV to 4.00 eV, sementara itu bagi  $m=2$  pula adalah dari 2.86 eV hingga 3.60 eV.

Bagi campuran MeG dop PVB/CH telah menunjukkan tiada berlaku perubahan warna, tetapi mula meluntur pada purata dos kurang dari 25 kGy. Penyerapan pada puncak 425 nm, mencirikan warna kuning menurun dengan peningkatan dos. Sensitiviti dos,  $D_0$  meningkat di mana nilainya adalah 13.5, 16.7, 18.7 and 23.0 kGy bagi konsentrasi CH 2.0, 3.0, 4.0 dan 5.0 g masing-masing. Pada masa yang sama, penyerapan pada puncak 625 nm yang mencirikan warna hijau juga menurun dengan peningkatan dos. Sensitivity dos,  $D_0$  menurun di mana nilainya adalah 14.5, 16.4, 19.5 and 20.9 kGy bagi konsentrasi CH pada 2.0, 3.0, 4.0 dan 5.0 g masing-masing. Analisis dari Raman spectrometer menunjukkan keamatan ikatan C-Cl menurun dengan peningkatan dos. Sensitiviti dos,  $D_0$  di mana nilainya adalah 8.2, 9.5, 15.5 and 20.5 kGy bagi kandungan CH masing-masing pada 2.0, 3.0, 4.0 dan 5.0 g.

Nilai  $E_{opt}$  for campuran MeG dop PVB/CH jelas menurun dengan peningkatan dos tetapi ia tidak jelas kelihatan menurun dengan peningkatan kandungan CH. Nilai keseluruhannya menurun dari 3.68 eV hingga 3.25 eV sehingga dos 25 kGy dan pada kandungan CH dari 2.0 g hingga 5.0 g. Nilai  $\Delta E$  didapati meningkat dengan pertambahan dos dan juga kandungan CH. Nilainya tidak jelas berubah pada dos 0 kGy iaitu dari 0.1010 hingga 0.1404 eV pada masing-masing 2g dan 5g. Nilai keseluruhannya meningkat dari 0.1010 eV hingga 0.7355 eV pada dos sehingga 25 kGy dan pada kandungan CH dari 2 g hingga 5 g. Nilai  $E_g$  bagi campuran MeG dop PVB/CH

menurun dengan peningkatan dos dan kandungan CH bagi  $m=1/2$  dan  $m=2$ . nilai  $E_g$  pada  $m=1/2$  adalah 3.79 eV to 3.57 eV, sementara itu nilai  $E_g$  pada  $m=2$  adalah dari 3.62 eV hingga 2.90 eV.

Didapati bahawa filem blend CV dop PVA/CH dan MeG dop PVB/CH yang diradiasikan dengan sinar  $\gamma$  memberikan kesan terhadap ciri-ciri pengukur dos dan optik.

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I certify that an Examination Committee met on 4<sup>th</sup> May 2005 to conduct the final examination of Azlina binti Baha on her Master of Science thesis entitled “Effects of Radiation on Dosimetric and Optical Properties of Dyed PVA-CH and Dyed PVB-CH Composites” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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## DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.



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**AZLINA BINTI BAH**

Date: 17 JUNE 2005

## TABLE OF CONTENTS

<b>DEDICATIONS</b>	Page ii
<b>ABSTRACT</b>	iii
<b>ABSTARK</b>	vii
<b>ACKNOWLEDGEMENTS</b>	xi
<b>APPROVAL SHEET</b>	xii
<b>DECLARATION</b>	xiv
<b>LIST OF TABLES</b>	xviii
<b>LIST OF FIGURES</b>	xx
<b>LIST OF PLATES</b>	xxiv
<b>LIST OF SYMBOLS AND ABBREVIATIONS/NOTATIONS</b>	xxv
<b>CHAPTER</b>	
<b>1 INTRODUCTION</b>	
General Introduction	1
Radiation Dosimetry	3
Dyed Polymer Dosimeter	5
Problem Statement	7
Objectives of the Study	9
Outline of the Thesis	10
<b>2 LITERATURE REVIEW</b>	
Introduction	12
Physical and Chemical Effects Irradiated Materials	13
Radiation Processing	16
Medical Device Sterilization	16
Food Irradiation	17
Modification of Polymer	18
Radiation Dosimetry	19
Polymer Blended with Organic Compounds	21
Polyvinyl alcohol (PVA) Dyed Film	24
Polyvinyl butyral (PVB) Dyed Film	25
<b>3 THEORY</b>	
Interaction of Ionizing Radiation with Matter	27
Nature Radiation	28
Electromagnetic Radiation	28
The Electromagnetic Spectrum	28
Interaction of Photon	29
Photoelectric Effect	30
Pair Production	31
Campton Effect	32
Effect of Ionizing Radiation in Molecules and Polymer	32
Principle of Molecular Structure	33





Basic Concept of Radiation Chemistry	33
Radiation Effects on Polymer Systems	35
Structural Factors Affecting Light Stability of Dyed Polymers	36
Raman Spectroscopy	37
UV/Visible Spectroscopy	41
Fundamental of Molecular Absorption Spectroscopy (UV/Visible)	42
Electronic Transitions in Molecules	45
The Beer-Lambert-Bouguer Law	47
Activation Energy	48
Energy Band Gap	49
<b>4 METHODOLOGY</b>	
Introduction	51
Preparation of Stock Solution of Indicator	
Crystal Violet	51
Methyl Green	52
Film Preparation	
CV Doped PVA/CH Blends	53
MeG Doped PVB/CH Blends	54
Irradiation Procedure	55
Apparatus and Spectra Measurements	
UV/Visible Spectrometer	57
Raman Spectrometer	59
<b>5 RADIATION EFFECT ON OPTICAL ABSORPTION PROPERTIES</b>	
Dosimetric Characteristic of CV Dyed PVA-CH Blend	62
UV/Visible Absorption Spectra	62
Dosimetric Dose Property of Absorption Spectra	68
Raman Scattering Spectra	72
Dosimetric Dose Response of Raman Spectra	75
Optical Characteristic of CV Dyed PVA-CH Blend	79
Absorption Edge, $E_{opt}$	79
Optical Activation Energy, $\Delta E$	84
Optical Band Gap Energy, $E_g$	90
Dosimetric Characteristic of MeG Dyed PVB-CH Blend	100
UV/Visible Absorption Spectra	100
Dosimetric Dose Property of Absorption Spectra	105
Raman Scattering Spectra	109
Dosimetric Dose Response of Raman Spectra	112

Optical Characteristic of MeG Dyed PVB-CH Blend	115
Absorption Edge, $E_{\text{opt}}$	115
Optical Activation Energy, $\Delta E$	120
Optical Band Gap Energy, $E_g$	126
 <b>6 CONCLUSION AND SUGGESTIONS FOR FUTURE WORK</b>	
Conclusions	135
Suggestions for Future Work	138
 <b>REFERENCES</b>	139
 <b>BIODATA OF THE AUTHOR</b>	150

## LIST OF TABLES

Table		Page
1.1	Advantage and disadvantage of integrating dosimetry	7
3.1	Photon Interactions	30
3.2	An absorption of a simple chromopheres	45
5.1	Absorbed dose require to change colour from violet to blue of CV doped PVA/CH blends containing different concentrations of CH at different doses	66
5.2	$D_O$ of the dose response curves at 590 nm and 620 nm bands for CV doped PVA/CH blends at different CH concentrations	71
5.3	$D_O$ of the Raman dose response curves of band at range 800 $\text{cm}^{-1}$ for CV doped PVA/CH blends at different concentrations of CH	77
5.4	Absorption edge position (eV) at different doses and CH concentration of CV doped PVA/CH blends	82
5.5	Effect gamma irradiation on the optical activation energy of CV doped PVA/CH blends	88
5.6	Variation of the direct energy band gaps of CV doped PVA/CH blends at different doses and CH concentration	94
5.7	Variation of the indirect energy band gaps of CV doped PVA/CH blends at different doses and CH concentration	97
5.8	$D_O$ of the dose response curves at 425 nm and 650 nm bands for MeG doped PVB/CH blends with different CH concentration	107
5.9	$D_O$ of the Raman dose response curves of band at range 800 $\text{cm}^{-1}$ for MeG doped PVB/CH blends	113
5.10	$E_{\text{opt}}$ (eV) at different doses and CH concentration of MeG doped PVB/CH blends	118
5.11	Effect gamma irradiation on the $\Delta E$ of MeG doped PVB/CH blends	123



5.12	Variation of the direct energy band gaps of MeG doped PVB/CH blends at different doses and CH concentration	129
5.13	Variation of the indirect energy band gaps of MeG doped PVB/CH blends at different doses and CH concentration	132

## LIST OF FIGURES

Figure		Page
2.1	Typical traceability chain for high dose dosimetry (Arne <i>et. al.</i> , 2000)	19
2.2	Film colour change upon irradiation of gamma ray (Ebraheem <i>et. al.</i> , 2002)	22
2.3	Film bleaching colour upon irradiation of gamma ray (Abdel-Fattah <i>et. al.</i> , 1999)	23
3.1	The electromagnetic spectrum	29
3.2	Represents Rayleigh, Stokes and Anti-Stokes scattering of molecular vibration	40
3.3	A schematic of sample compound absorb light	42
3.4	Rotational and vibrational electronic levels	43
3.5	An example of the absorption spectrum	44
3.6	Possible electronic transitions of $\pi$ , $\sigma$ and $n$ electrons	45
3.7	Pictorially using a band diagram	50
4.1	Accessory equipment of J.L. Shepherd $^{60}\text{Co}$ chamber	56
4.2	Schematic of a single beam UV/Visible spectrometer	58
4.3	<i>in-vivo</i> fibre-optic Raman sampling configuration	60
5.1	The absorption spectra of unirradiated and irradiated CV doped PVA/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g, and (d) 5 g CH	64
5.2	(a) Basic form of crystal violet dye and (b) Strong acidic form of crystal violet dye	67
5.3	The dose response curves of the CV doped PVA/CH blends for 590 nm band at different CH concentrations irradiated at different doses	70

5.4	The dose response curves of the CV doped PVA/CH blends for 620 nm band at different CH concentrations irradiated at different doses	70
5.5	The dose sensitivity, $D_0$ of the CV doped PVA/CH blends (bands 590 nm and 620 nm) at different CH concentrations exposed at different doses. The error bars shown are for 3% corrections	72
5.6	The Raman spectra of CV doped PVA/CH blend with (a) 2 g, (b) 3 , (c) 4 and (d) 5 g CH unirradiated and irradiated at different absorbed doses	75
5.7	The dose response curves of the CV doped PVA/CH blends 780 $\text{cm}^{-1}$ band at different CH concentrations irradiated at different doses	76
5.8	The dose sensitivity, $D_0$ of the CV doped PVA/CH blends peaking at 780 $\text{cm}^{-1}$ band at different CH concentrations irradiated at different doses	78
5.9	$\alpha$ ( $\nu$ ) as a function of $h\nu$ of CV doped PVA/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	81
5.10	$E_{\text{opt}}$ (eV) as a function of dose (kGy) for CV doped PVA/CH blend films	83
5.11	$E_{\text{opt}}$ (eV) as a function of CH concentration (g) for CV doped PVA/CH blend films	88
5.12	$\ln \alpha$ as a function of $h\nu$ of CV doped PVA/CH blends at different doses for 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	83
5.13	$\Delta E$ (eV) as a function of dose (kGy) $h\nu$ (eV) for CV doped PVA/CH blend films	87
5.14	$\Delta E$ (eV) as a function of CH concentration (g) for CV doped PVA/CH blend films	89
5.15	Direct allowed transition $(\alpha h\nu)^2$ as a function of $h\nu$ of CV doped PVA/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	93
5.16	Indirect allowed transition $(\alpha h\nu)^{1/2}$ as a function of $h\nu$ at different doses of CV doped PVA/CH blends at different doses for (a) 2g, (b) 3g, (c) 4g and (d) 5g CH	96
5.17	Variation of the direct optical band gaps energy of CV doped PVA/CH blends at different doses and CH concentration	98

5.18	Variation of the indirect optical band gaps energy of CV doped PVA/CH blends at different doses and CH concentration	98
5.19	The absorption spectra of unirradiated and irradiated MeG/PVB-CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	102
5.20	Molecule structure of methyl green dye	103
5.21	The dose response curves of the MeG doped PVB/CH blends for 425 nm band at different CH concentrations at different doses	106
5.22	The dose response curves of the MeG doped PVB/CH blends for 650 nm band at different CH concentrations at different doses	106
5.23	The dose sensitivity, $D_0$ of the MeG doped PVB/CH blends (bands 425 nm and 650 nm) at different CH concentration exposed at different doses	108
5.24	The Raman spectra of MeG doped PVB/CH blends with (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH unirradiated and irradiated at different absorbed doses	111
5.25	The dose response curves of MeG doped PVB/CH blends with different CH concentration peaking at $780\text{ cm}^{-1}$ band exposed at different doses	112
5.26	The dose sensitivity, $D_0$ of MeG doped PVB/CH blends peaking at $780\text{ cm}^{-1}$ band at different CH concentration exposed at different doses	114
5.27	$\alpha$ (v) as a function of $h\nu$ of MeG doped PVB/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	117
5.28	$E_{opt}$ (eV) as a function of dose (kGy) of MeG doped PVB/CH blends	119
5.29	$E_{opt}$ (eV) as a function of CH concentration (g) of MeG doped PVB/CH blends	119
5.30	$\ln \alpha$ as a function of $h\nu$ of MeG doped PVB/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	122
5.31	$\Delta E$ (eV) as a function of dose (kGy) of MeG doped PVB/CH blends	124
5.32	$\Delta E$ (eV) as a function of CH concentration of MeG doped PVB/CH blend	124

5.33	Direct allowed transition $(\alpha h\nu)^2$ as a function of $h\nu$ at different doses of MeG doped PVB/CH blends at different doses for (a) 2 g, (b) 3 g, (c) 4 g and (d) 5 g CH	128
5.34	Variation of the indirect energy band gaps of MeG doped PVB/CH blends at different doses and CH concentration	136
5.35	Optical band gap energy ( $m=1/2$ ) as a function of dose (kGy) for MeG doped PVB/CH blends with different CH concentration at different doses	136
5.36	Optical band gap energy ( $m=2$ ) as a function of dose (kGy) for MeG doped PVB/CH blends with different CH concentration at different doses	133



## LIST OF PLATES

Plates	Page
4.1 Crystal violet dye solution	52
4.2 Methyl green dye solution	52
4.3 CV doped PVA/CH blend films	54
4.4 MeG doped PVB/CH blend films	55
4.5 J.L. Shepherd $^{60}\text{Co}$ chamber at MINT Bangi	57
4.6 Shimadzu 3101 UV-Vis-NIR Spectrometer	59
4.7 Raman spectrometer (RSI 2001, Raman System, INC) equipped with 532 nm solid-state diode green laser	61